US009044850B2

(12) **United States Patent**
Kokinelis et al.

(10) **Patent No.: US 9,044,850 B2**
(45) **Date of Patent: Jun. 2, 2015**

(54) **TWIST LOCK GEAR CASE FOR POWER TOOLS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 588 days.

(21) Appl. No.: **13/431,281**

(22) Filed: **Mar. 27, 2012**

(65) **Prior Publication Data**

US 2013/0025900 A1 Jan. 31, 2013

Related U.S. Application Data

(60) Provisional application No. 61/512,183, filed on Jul. 27, 2011.

(51) **Int. Cl.**
B25F 5/02 (2006.01)
B25F 5/00 (2006.01)

(52) **U.S. Cl.**
CPC ***B25F 5/02*** (2013.01)

(58) **Field of Classification Search**
CPC B25F 5/02; B25F 5/00; B25F 5/006
USPC 173/216, 217, 170, 162.2; 310/50; 16/110.1
See application file for complete search history.

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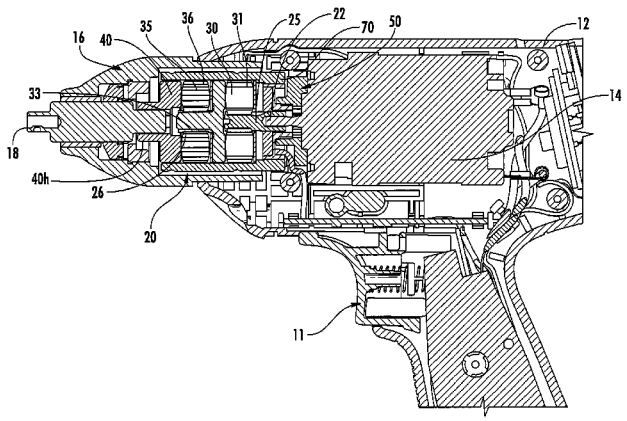
(74) *Attorney, Agent, or Firm* — Sunstone IP

(57) **ABSTRACT**

A power tool includes a motor having an outwardly extending rotor that defines a drive axis, a housing surrounding the motor, and a gearcase that includes a drive train coupled to the rotor and configured to drive a tool output. The gearcase includes a proximal end and an opposite distal end that is exposed to the outside of the tool forward of the housing. The gearcase includes respective locking elements spaced around the periphery of the gearcase proximal end. A motor mount includes spaced apart locking elements that are configured to engage with respective gearcase locking elements. The proximal end portion of the gearcase is adapted to make contact with the motor mount between the locking elements and then rotate such that the gearcase locking elements engage the motor mount locking elements.

20 Claims, 14 Drawing Sheets



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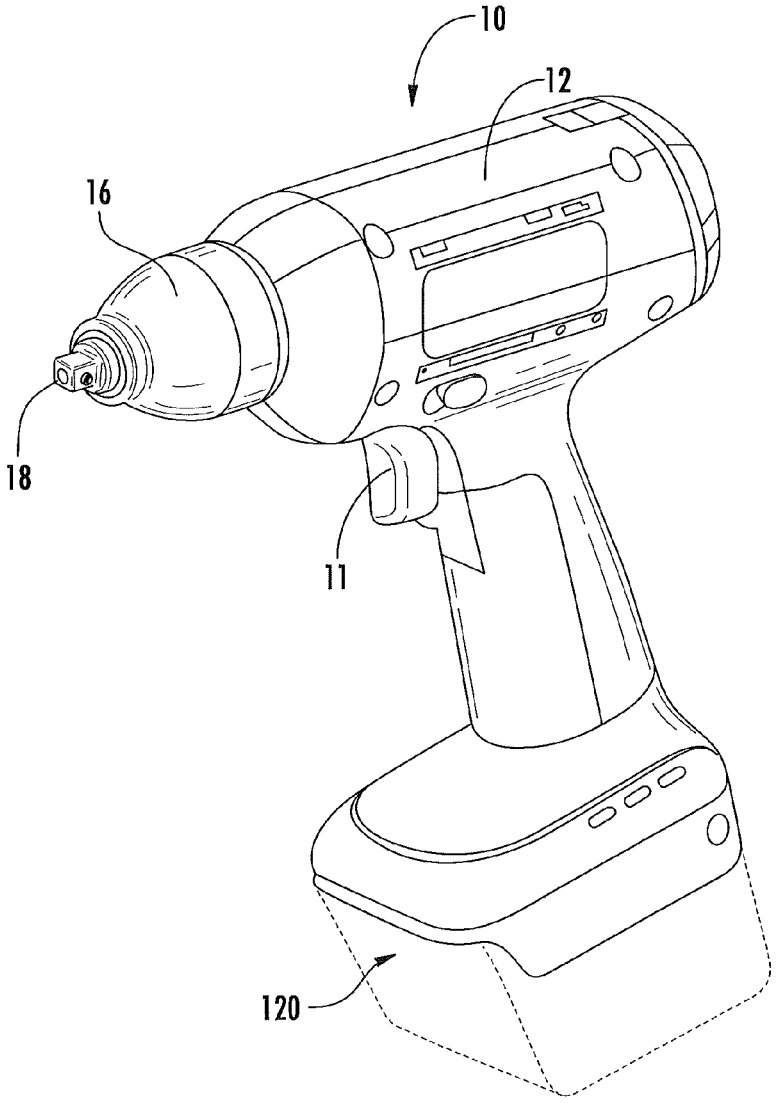


FIG. 1

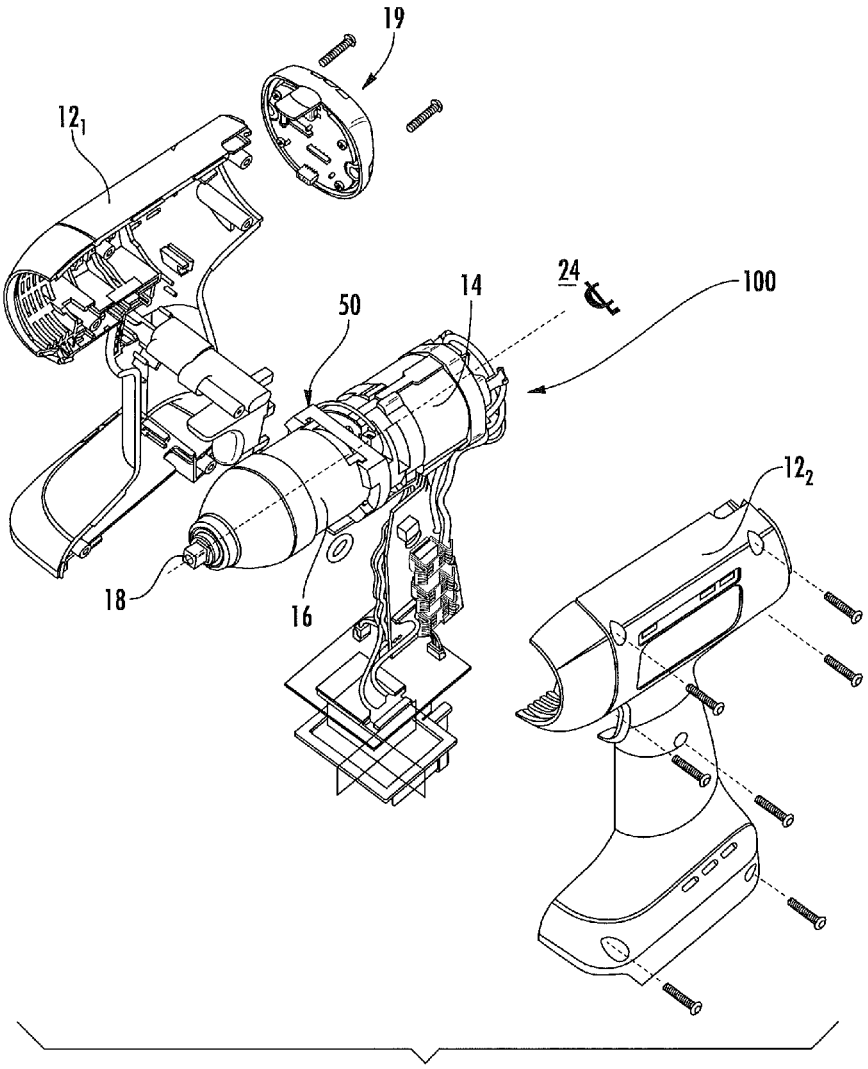


FIG. 2

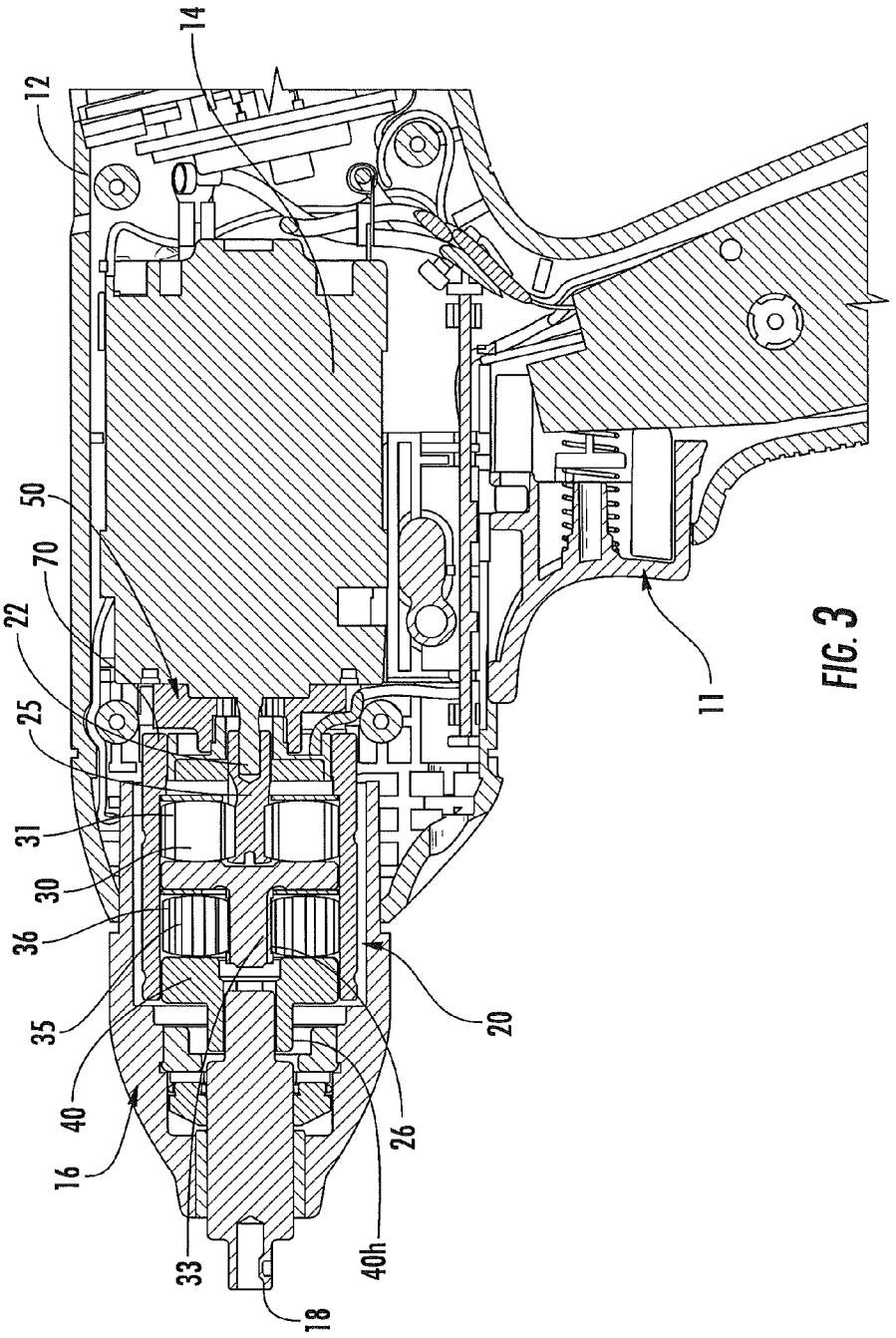


FIG. 3

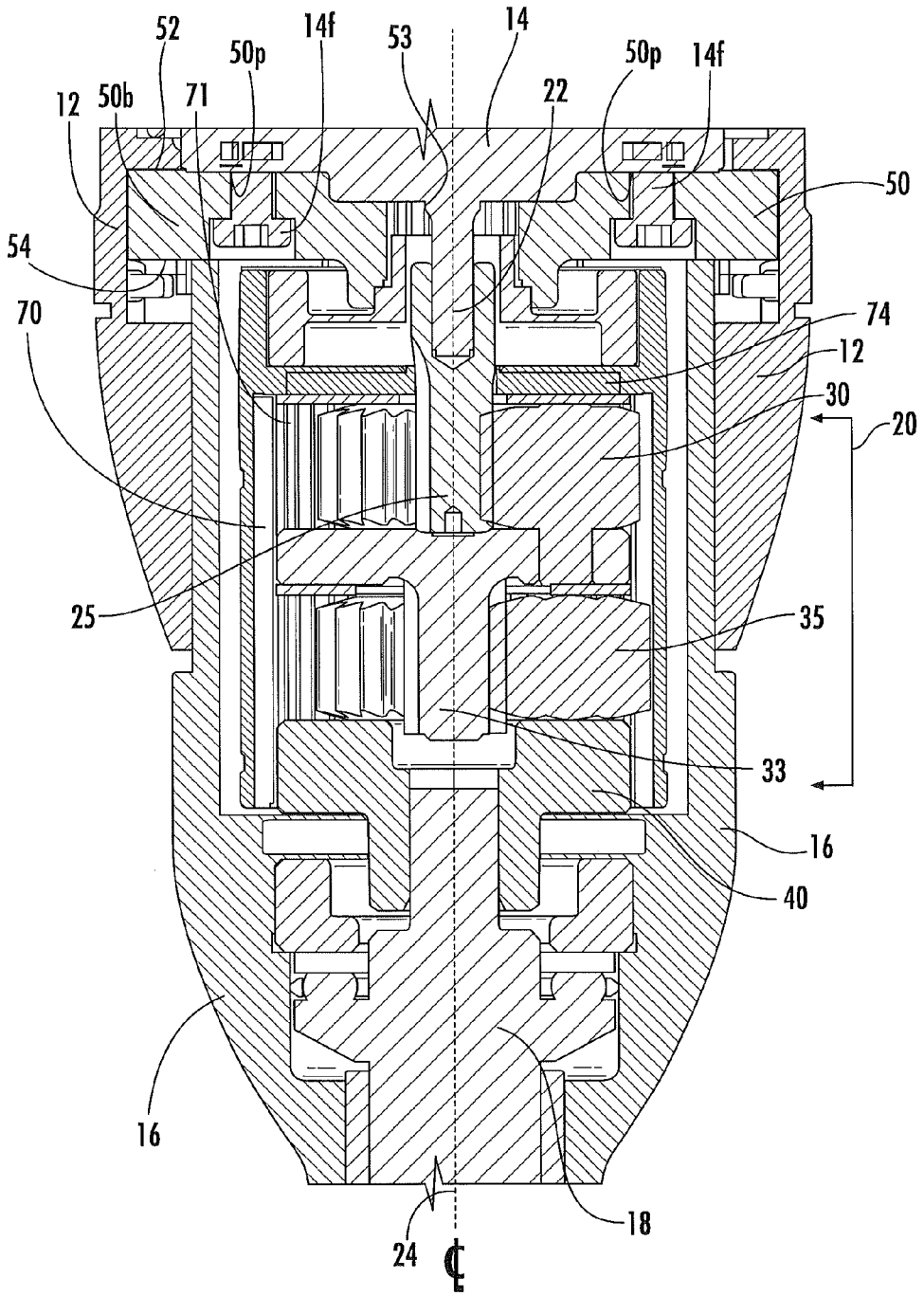
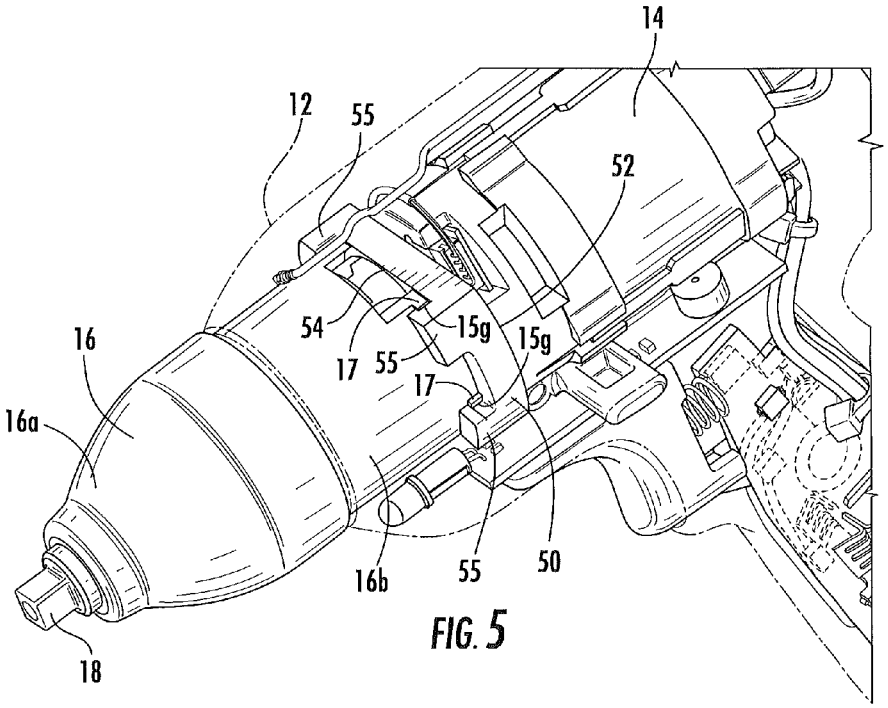

52
14f
53
14
50p
50p
14f
12
50b
71
22
50
54
70
74
12
30
20
25
35
33
16
40
16
18
24

FIG. 4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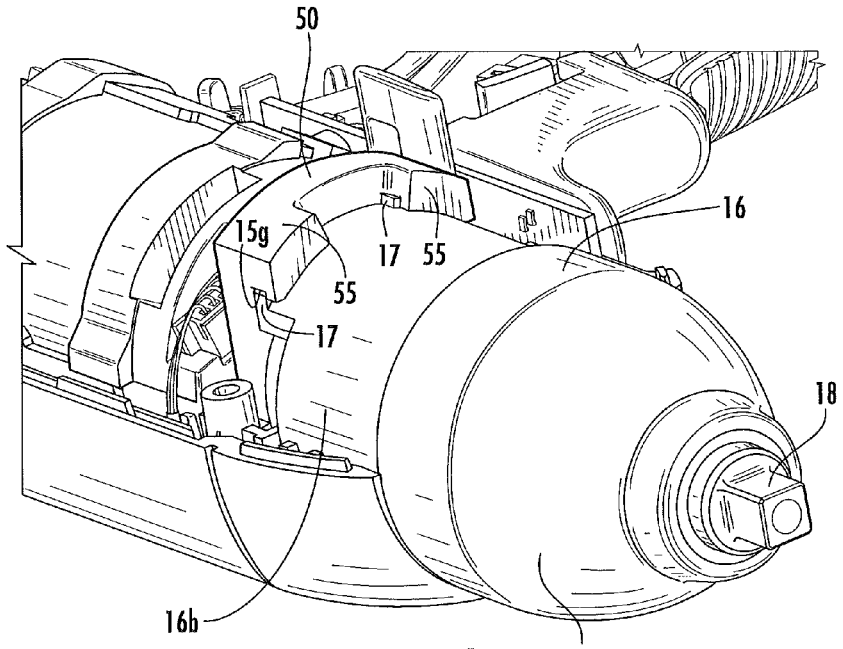
12
55
52
54
15g
15g
16
17
55
17
16a
16b
55
50
18

FIG. 5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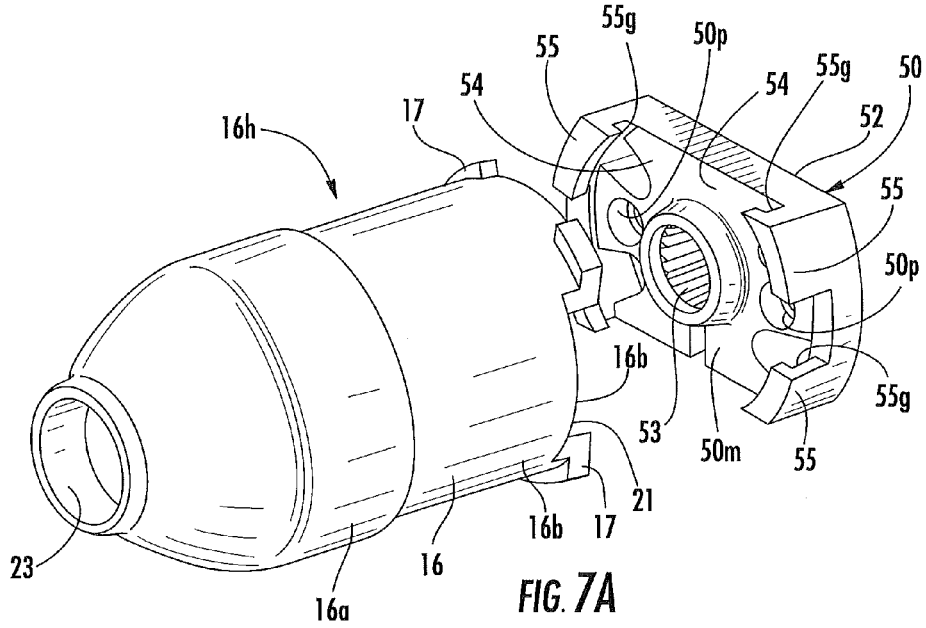
16
15g
17
55
55
17
18
16b
16a

FIG. 6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50p
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54
55g
50
54
52
17
16h
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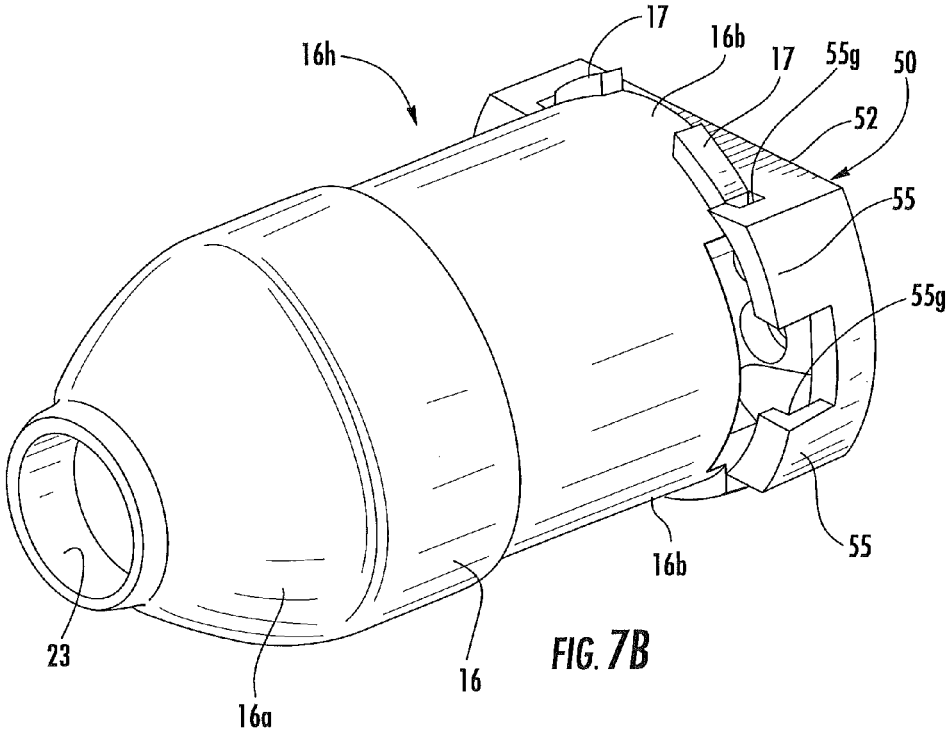
50p
16b
55g
53
50m
55
21
16b
17
23
16
16a

FIG. 7A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16b
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55g
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52
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55g
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16b
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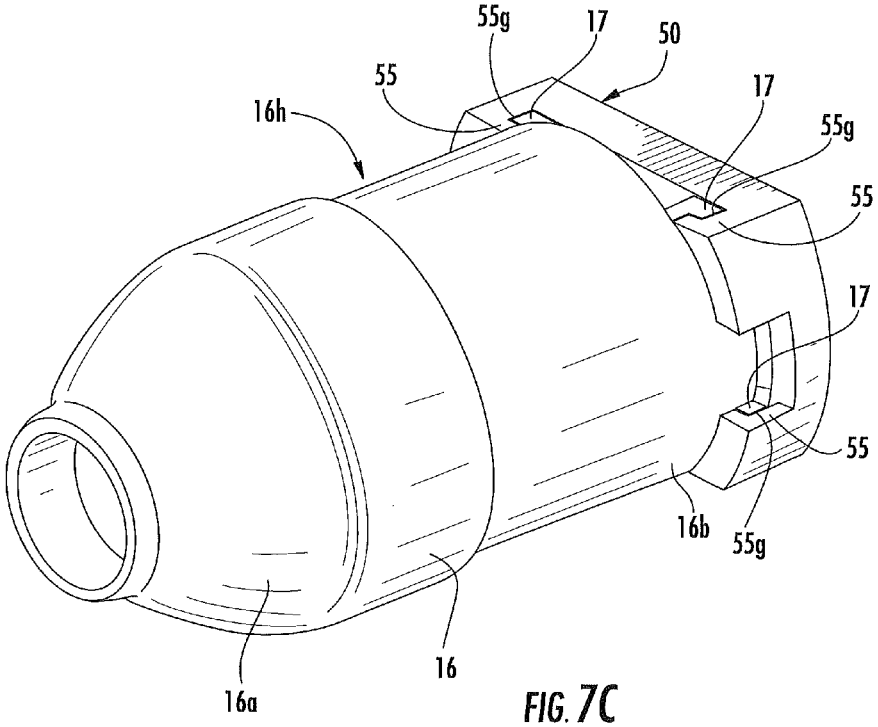
16
16a

FIG. 7B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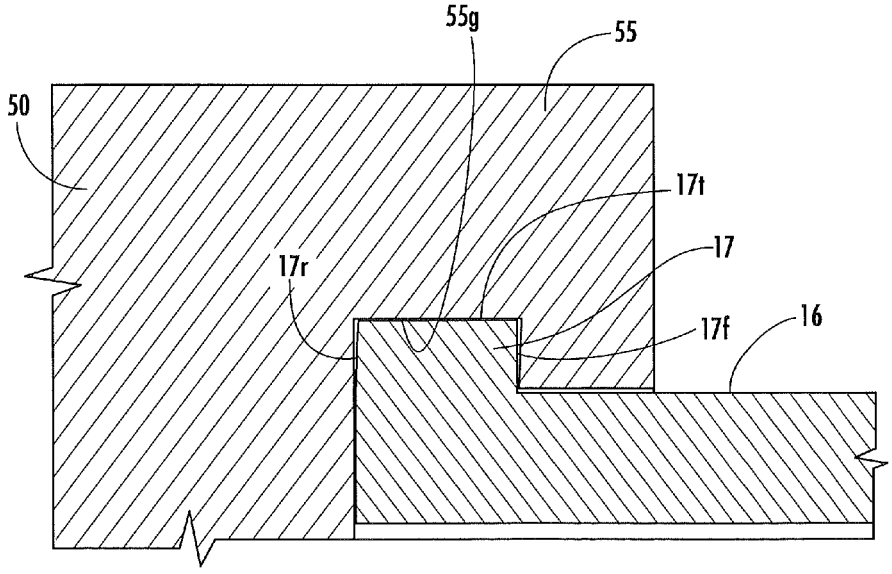
50
55
17
16h
55g
55
17
55
16b
55g
16
16a

FIG. 7C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17t
17
17r
17f
16

FIG. 8

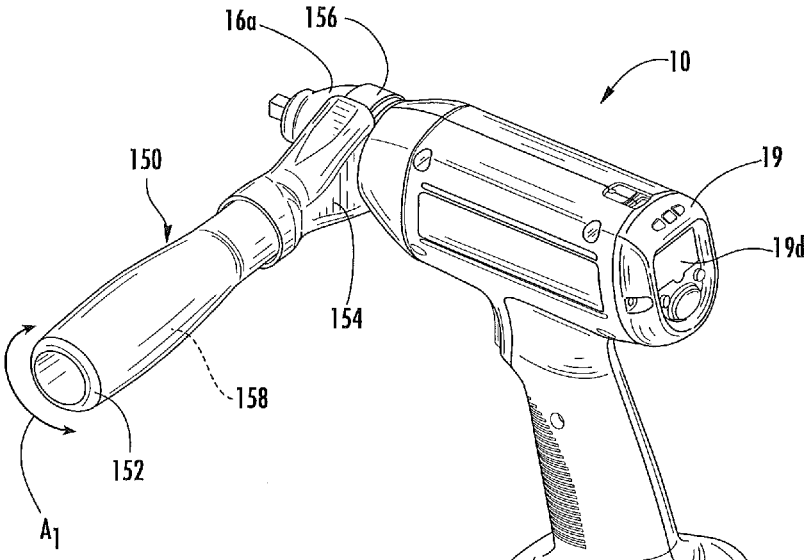

FIG. 9A

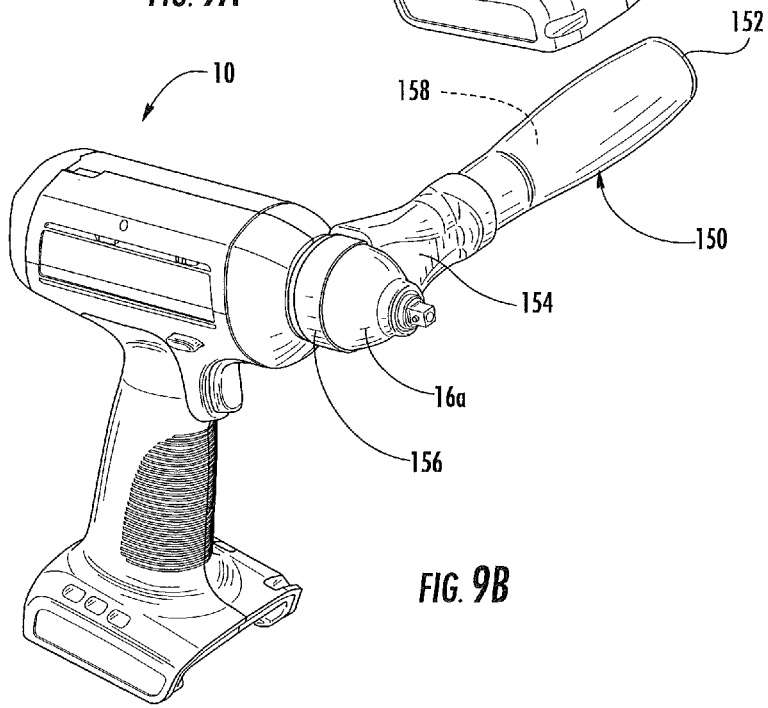

FIG. 9B

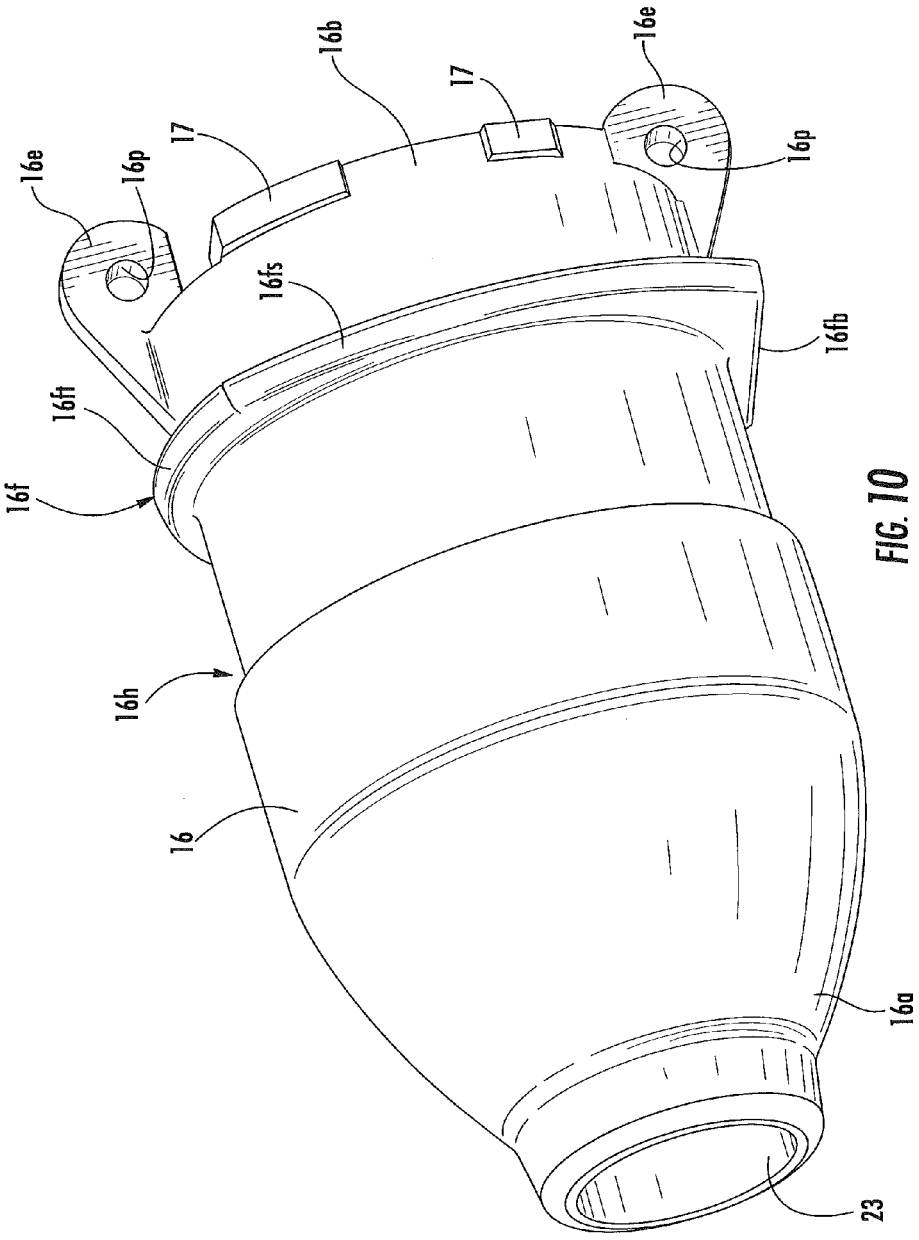

FIG. 10

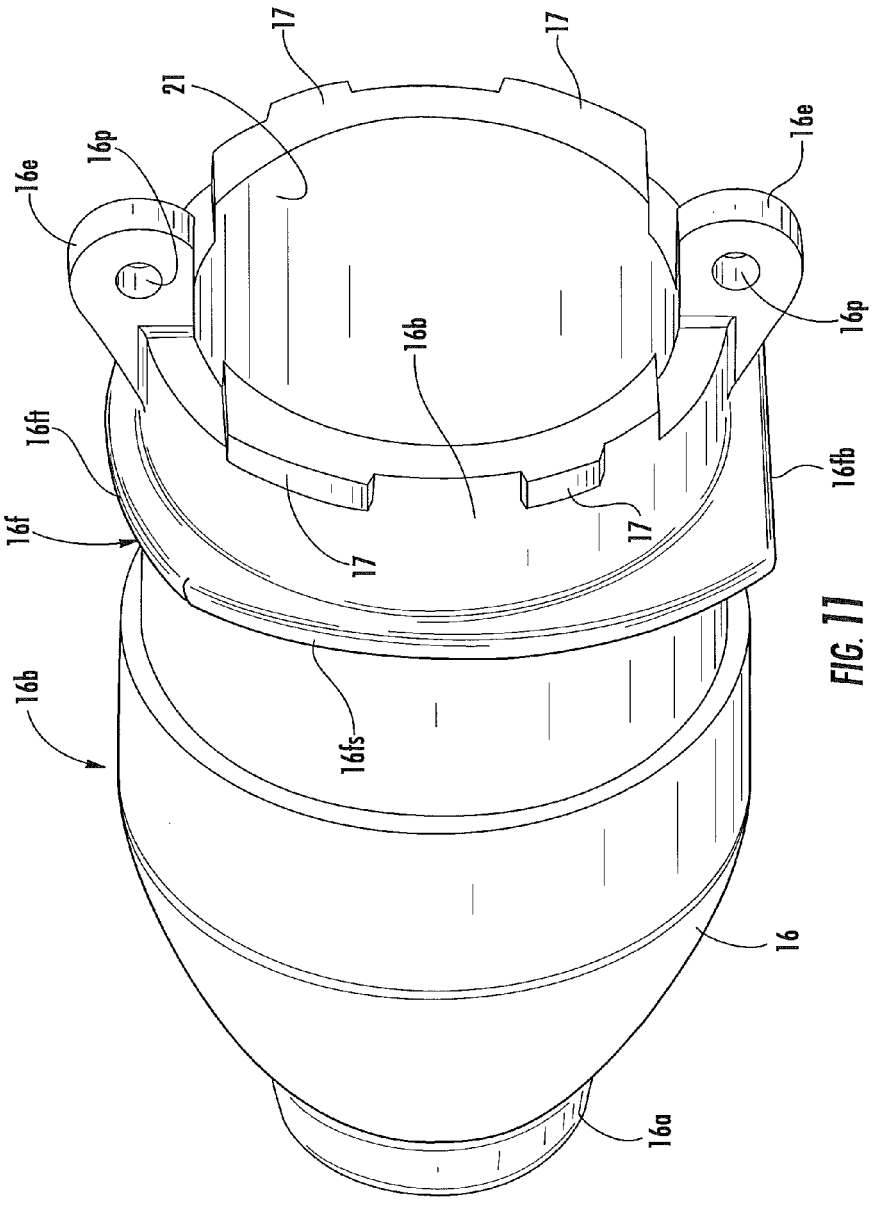

FIG. 11

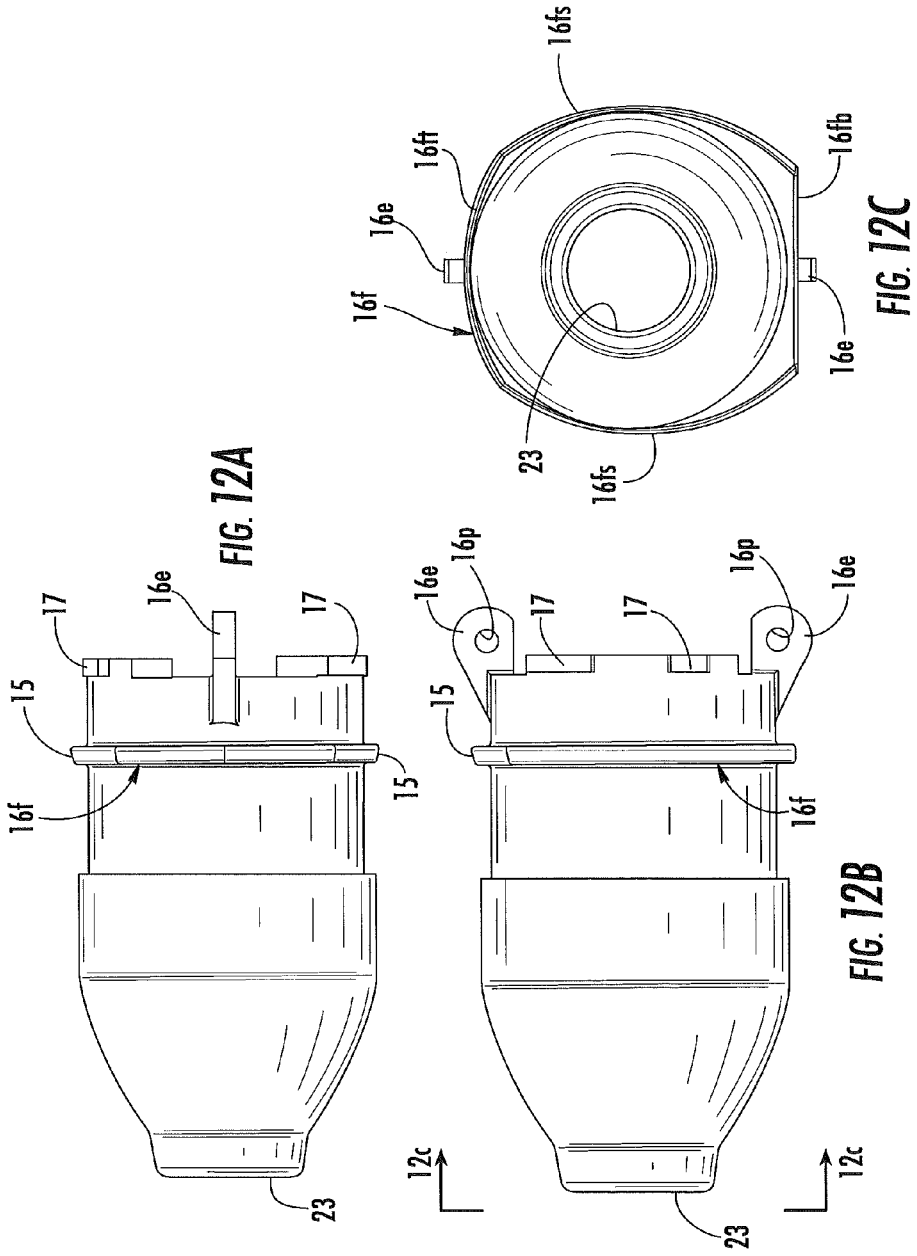

FIG. 12A

FIG. 12B

FIG. 12C

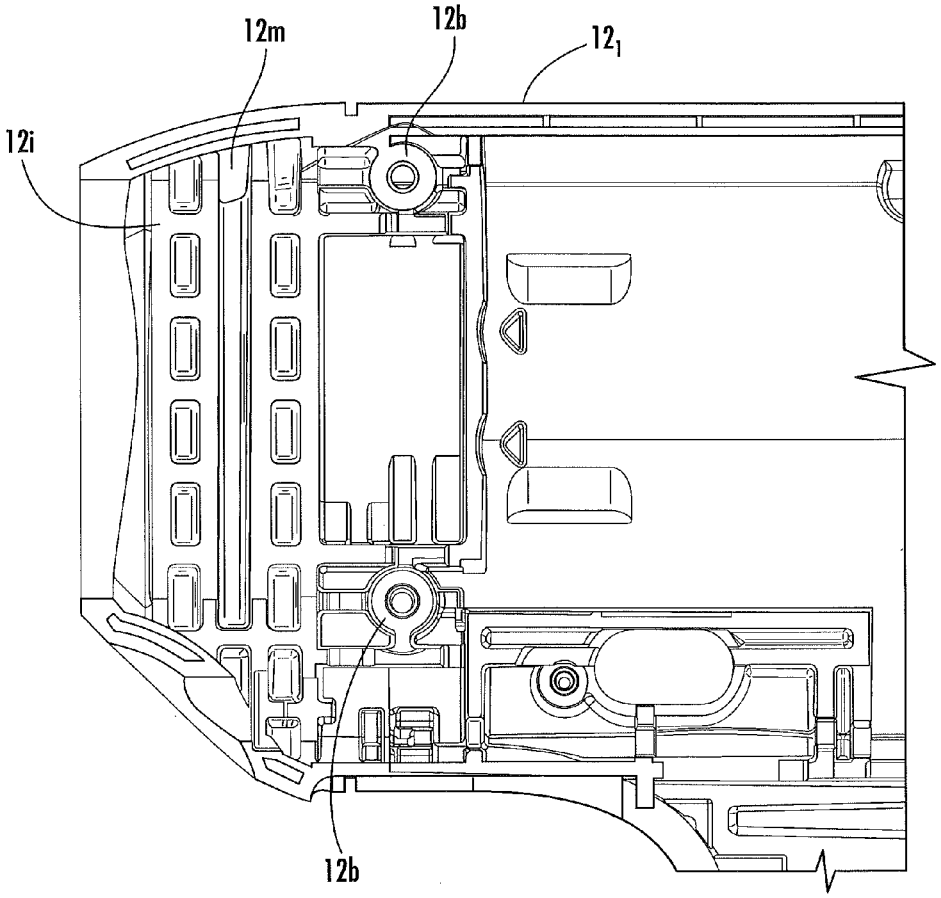

FIG. 13

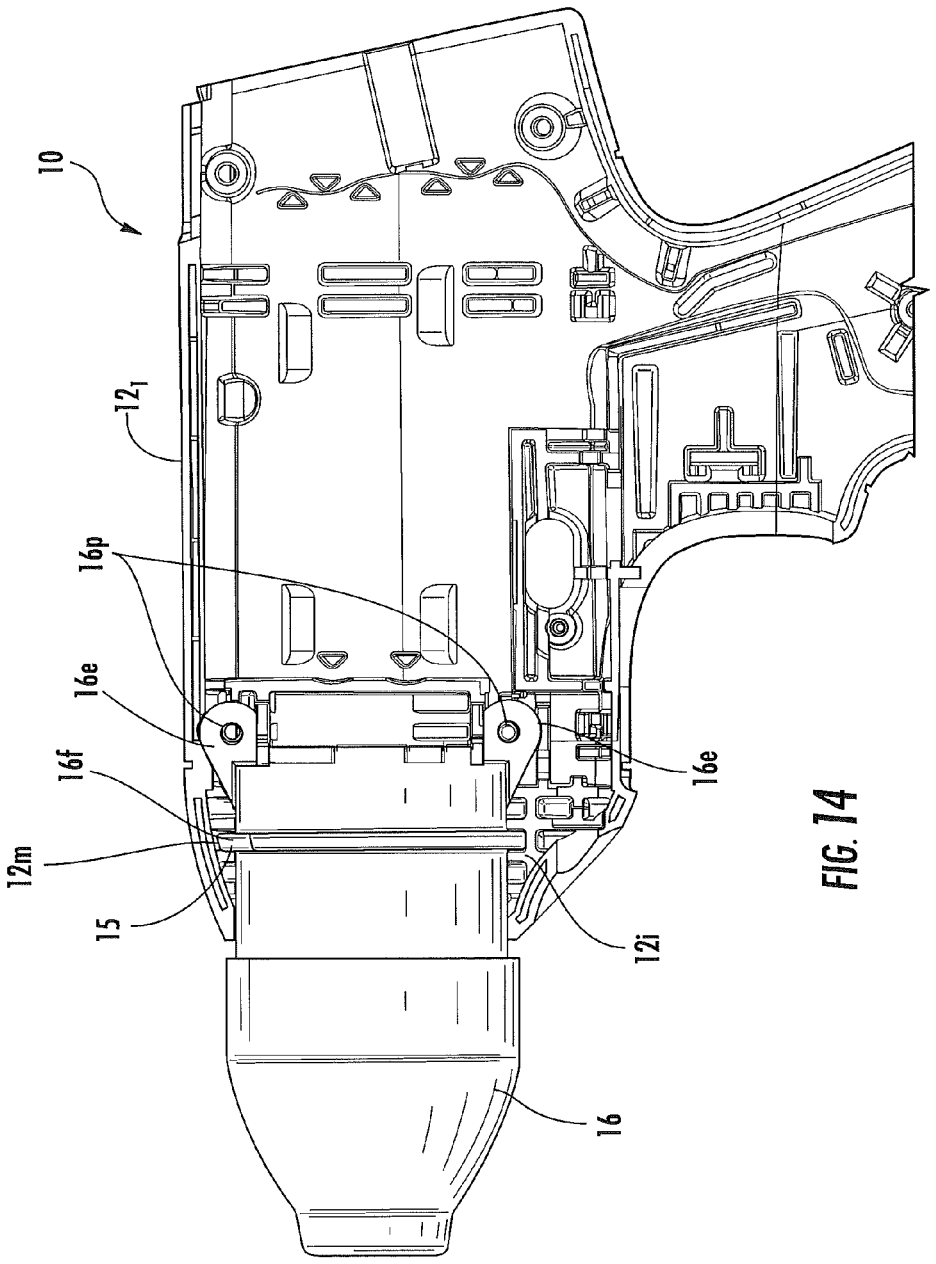

FIG. 14

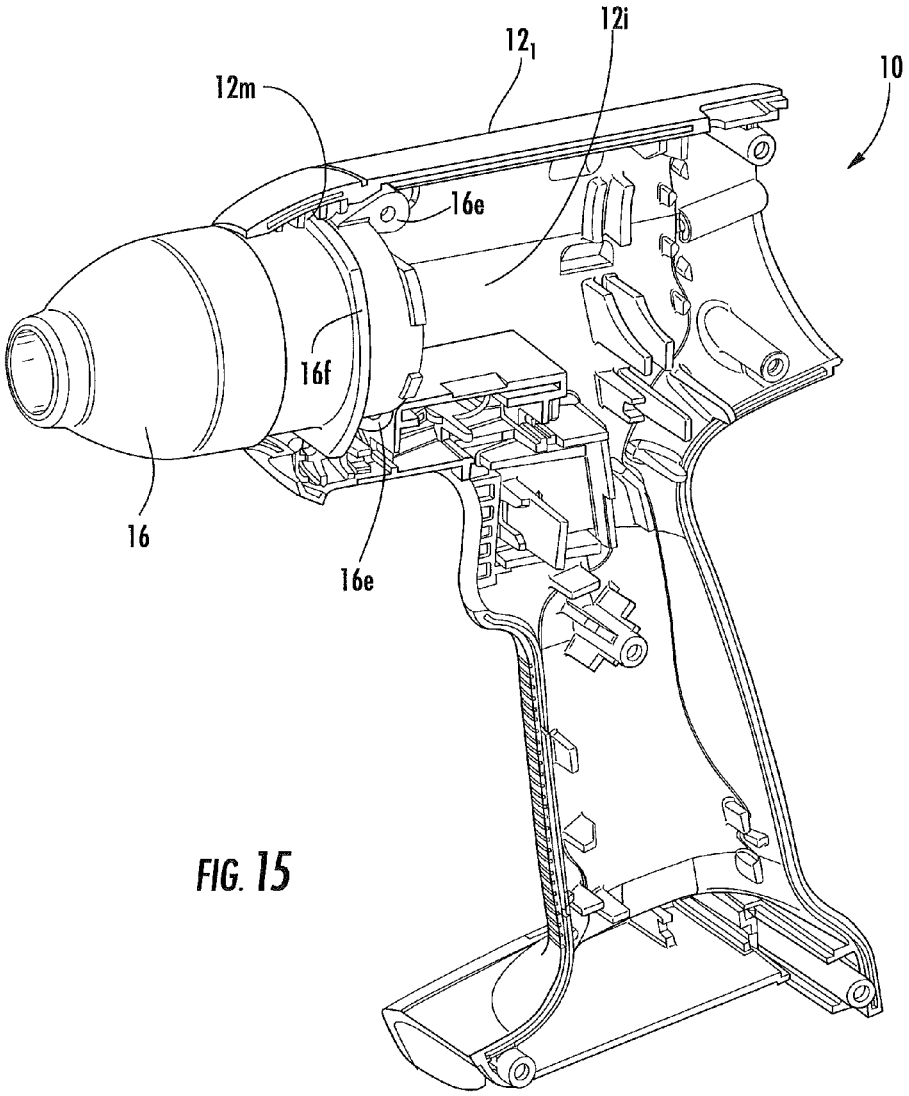

FIG. 15

TWIST LOCK GEAR CASE FOR POWER TOOLS

RELATED APPLICATIONS

This application claims the benefit of and priority to U.S. Provisional Patent Application No. 61/512,183, filed on Jul. 27, 2011, and to PCT Application No. PCT/US2011/030646, filed on Mar. 31, 2011, the contents of which are incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

This invention relates to power tools and is particularly suitable for cordless power tools.

BACKGROUND

Electric power tools, such as drills, nutrunners, and screwdrivers, generally include a housing supporting a motor, a drive train driven by the motor, an output shaft having a first end adapted to engage a fastener and a second end adapted to engage the drive train. Drive trains in these types of power tools need to remain concentric from the motor through the output shaft to avoid gearing misalignment and excessive gear noise.

SUMMARY

It should be appreciated that this Summary is provided to introduce a selection of concepts in a simplified form, the concepts being further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of this disclosure, nor is it intended to limit the scope of the invention.

According to some embodiments of the present invention, a power tool includes a motor having an outwardly extending rotor that defines a drive axis, a housing surrounding the motor, and a gearcase that encases a drive train coupled to the rotor and configured to drive a tool output. The gearcase includes a proximal end and an opposite distal end that is exposed to the outside of the tool forward of the housing. The gearcase is rigid enough to support an auxiliary handle in some embodiments of the present invention. A motor mount disposed within the housing includes opposite first and second sides. The motor is secured to the motor mount first side and the gearcase is secured to the motor mount second side such that the drive train is aligned concentrically with the rotor.

The gearcase includes respective locking elements spaced around the periphery of the gearcase proximal end. In some embodiments of the present invention, each locking element extends radially outward from the gearcase and has a tapered configuration. The motor mount includes spaced apart locking elements on the second side thereof that are configured to engage with respective gearcase locking elements. In some embodiments of the present invention, each motor mount locking element includes an arcuate groove that slidably receives a respective gearcase locking element. The proximal end portion of the gearcase is adapted to make contact with the motor mount second side, then rotate such that the gearcase locking elements slidably engage the motor mount locking elements.

According to some embodiments of the present invention, a gearcase for a power tool comprises an elongated housing having opposite, longitudinally spaced apart first and second end portions. The housing is configured to encase a drivetrain of the power tool. The first end portion has an opening configured to receive a rotor from a motor of the power tool that couples with the drive train, and the second end portion has an opening through which an output shaft of the power tool can extend. A plurality of locking elements are spaced peripherally from each other at the first end portion of the housing and are slidably engageable with respective locking elements on a motor mount of the power tool to which the gearcase is secured. In some embodiments of the present invention, the gearcase locking elements extend outward axially from a periphery of the first end portion of the housing. In some embodiments of the present invention, the gearcase locking elements have a tapered configuration that cause an interference fit with respective motor mount locking elements.

In some embodiments of the present invention, the first end portion of the gearcase housing includes a pair of mounting lugs extending outwardly therefrom that are configured to be secured to a housing of the power tool. In some embodiments of the present invention, a flange extends outwardly from and around an outer surface of the gearcase housing and is configured to engage an interior portion of the housing of the power tool.

According to some embodiments of the present invention, a motor mount for a power tool includes a base having opposite first and second sides. The base first side is configured to be attached to a motor of the power tool, and the base second side is configured to be attached to a gearcase that encases a drivetrain of the power tool. An opening extends through the base between the first and second sides and is configured to receive a motor rotor therethrough that couples with the drive train. A plurality of locking elements are located at the base second side that are configured to secure the gearcase to the base. The locking elements are spaced from each other and are engageable with respective gearcase locking elements by rotative motion of the gearcase relative to the motor mount. In some embodiments of the present invention, each motor mount locking element comprises an arcuate groove configured to slidably receive a respective gearcase locking element therein.

It is noted that aspects of the invention described with respect to one embodiment may be incorporated in a different embodiment although not specifically described relative thereto. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination. Applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to be able to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner. These and other objects and/or aspects of the present invention are explained in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which form a part of the specification, illustrate some exemplary embodiments. The drawings and description together serve to fully explain the exemplary embodiments.

FIG. **1** is a side perspective view of an exemplary cordless power tool, according to some embodiments of the present invention.

FIG. **2** is an exploded view of the tool shown in FIG. **1**.

FIG. **3** is a side section view of the power tool shown in FIG. **1**, according to some embodiments of the present invention.

FIG. **4** is a top section view of a portion of the power tool shown in FIG. **1**, according to some embodiments of the present invention.

FIG. **5** is a side perspective view of a portion of the tool shown in FIG. **1** with the housing transparent to illustrate the gearcase secured to the motor mount, according to some embodiments of the present invention.

FIG. **6** is a partial front perspective view of the tool shown in FIG. **5**, with a part of the housing omitted.

FIG. **7**A is an exploded perspective view of the gearcase and motor mount of the tool shown in FIG. **5**.

FIG. **7**B illustrates the gearcase and motor mount of FIG. **7**A in contacting relationship prior to securing the gearcase to the motor mount by rotating the gearcase relative to the motor mount.

FIG. **7**C illustrates the gearcase and motor mount of FIG. **7**B after clockwise rotation of the gearcase relative to the motor mount such that the gearcase is secured to the motor mount.

FIG. **8** is an enlarged cross-sectional view of one of the gearcase locking elements engaged with a respective motor mount locking element, according to some embodiments of the present invention.

FIG. **9**A is a top rear perspective view of the tool of FIG. **1** with an auxiliary handle removably secured to the gearcase, according to some embodiments of the present invention.

FIG. **9**B is a top front perspective view of the tool of FIG. **9**A.

FIG. **10** is a front perspective view of a gearcase for use with a cordless power tool, such as the tool of FIG. **1**, according to some embodiments of the present invention.

FIG. **11** is a rear perspective view of the gearcase of FIG. **10**.

FIG. **12**A is a side view of the gearcase of FIG. **10**.

FIG. **12**B is a side view of the gearcase of FIG. **10** rotated ninety degrees.

FIG. **12**C is a front end view of the gearcase of FIG. **12**B taken along lines **12**C-**12**C.

FIG. **13** is an enlarged, partial side view of a housing section of the power tool of FIG. **1** and that illustrates a portion of the housing in which the gearcase flange of FIG. **10** matably engages, according to some embodiments of the present invention.

FIG. **14** is a side view of the gearcase of FIG. **10** positioned within a housing section of the power tool of FIG. **1**, according to some embodiments of the present invention.

FIG. **15** is a front perspective view of the gearcase of FIG. **10** positioned within a housing section of the power tool of FIG. **1**, according to some embodiments of the present invention.

DETAILED DESCRIPTION

The present invention will now be described more fully hereinafter with reference to the accompanying figures, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like numbers refer to like elements throughout. In the figures, certain components or features may be exaggerated for clarity, and broken lines may illustrate optional features or elements unless specified otherwise. In addition, the sequence of operations (or steps) is not limited to the order presented in the figures and/or claims unless specifically indicated otherwise. Features described with respect to one figure or embodiment can be associated with another embodiment of figure although not specifically described or shown as such.

It will be understood that when a feature or element is referred to as being "on" another feature or element, it can be directly on the other feature or element or intervening features and/or elements may also be present. In contrast, when a feature or element is referred to as being "directly on" another feature or element, there are no intervening features or elements present. It will also be understood that, when a feature or element is referred to as being "connected", "attached" or "coupled" to another feature or element, it can be directly connected, attached or coupled to the other feature or element or intervening features or elements may be present. In contrast, when a feature or element is referred to as being "directly connected", "directly attached" or "directly coupled" to another feature or element, there are no intervening features or elements present. Although described or shown with respect to one embodiment, the features and elements so described or shown can apply to other embodiments.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items and may be abbreviated as "/".

Spatially relative terms, such as "under", "below", "lower", "over", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if a device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly. Similarly, the terms "upwardly", "downwardly", "vertical", "horizontal" and the like are used herein for the purpose of explanation only unless specifically indicated otherwise.

It will be understood that although the terms first and second are used herein to describe various features or elements, these features or elements should not be limited by these terms. These terms are only used to distinguish one feature or element from another feature or element. Thus, a first feature or element discussed below could be termed a second feature or element, and similarly, a second feature or element discussed below could be termed a first feature or element without departing from the teachings of the present invention.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictio-

naries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

The term "cordless" power tool refers to a power tool that does not require plug-in, hard wired electrical connections to an external power source to operate. Rather, cordless power tools have electric motors that are powered by on-board batteries, such as rechargeable batteries. A range of batteries may fit a range of cordless power tools. Different cordless power tools may have a variety of electrical current demand profiles that operate more efficiently with batteries providing a suitable range of voltages and current capacities. The different cordless (e.g., battery powered) power tools can include, for example, drills, screwdrivers, ratchets, nutrunners, impacts and the like.

Embodiments of the present invention may be particularly suitable for precision power tools that can be used for applications where more exact control of the applied output is desired.

FIGS. **1** and **2** illustrate a power tool **10**, according to some embodiments of the present invention. The power tool **10** includes a housing **12**, a motor **14**, a gearcase **16** and a tool output shaft **18**. As shown, the housing **12** encases the motor **14** and partially surrounds the gearcase **16**. As illustrated in FIGS. **5** and **6**, a distal end portion **16***a* of the gearcase **16** has a tapered configuration and is exposed to the outside of the tool forward of the housing **12**. The gearcase **16** encloses a drive train **20** (FIGS. **3**, **4**). The lower portion of the housing **12** can releasably engage a battery **120** (shown in broken line in FIG. **1**). The housing **12** can include an external control such as a trigger **11** and a UI (user interface) **19** with a display **19***d* (FIG. **9**A).

As shown in FIGS. **2** and **4**, the motor **14** can be held in a desired fixed position and orientation in the housing **12** using a motor mount **50**. As illustrated in FIG. **4**, the motor mount **50** has a base **50***b* with opposite first and second sides **52**, **54**. The motor **14** is attached to the motor mount first side **52** via fasteners **14***f*, such as screws, bolts, threaded rods, and the like, that extend through respective passageways **50***p* in the motor mount base **50***b* (FIGS. **4**, **7**A).

Referring to FIGS. **7**A-**7**C, the gearcase **16** has an elongated housing **16***h* with opposite, longitudinally spaced apart distal and proximal end portions **16***a*, **16***b*. As noted above, the gearcase housing **16***h* is configured to encase a drivetrain of the power tool **10**. The proximal end portion **16***b* has an opening **21** configured to receive a rotor **22** (FIG. **3**) from the motor **14** of the power tool **10** that couples with the drive train **20** (FIG. **3**). The distal end portion **16***a* has an opening **23** through which an output shaft **18** of the power tool **10** extends. The gearcase housing **16***h* is rigidly mounted to the motor mount **50** second side **54** via gearcase locking elements **17** that cooperate with and slidably engage motor mount locking elements **55** creating a single unified drive train. As described below, the gearcase **16** can twist to matably secure to the motor mount **50** second side **54**. The gearcase **16** (and encased drive train **20**) with the motor mount **50** and motor **14** can define or form part of a motor sub-assembly **100** (FIG. **2**) that can be placed into the outer housing **12**, which as shown in FIG. **2**, may be provided as two matable sections $\mathbf{12}_1$, $\mathbf{12}_2$. In some embodiments, the matable housing sections $\mathbf{12}_1$, $\mathbf{12}_2$ are substantially symmetrical.

Referring to FIGS. **3** and **4**, the motor **14** includes a motor rotor **22** (e.g., motor output shaft) that extends through an opening **53** in the motor mount **50** toward the tool output shaft **18** and has a centerline that coincides with a drive train center axis **24**. The motor rotor **22** is attached to a pinion gear **25** having a plurality of splines or teeth **26**. The motor rotor **22** drives the pinion gear **25** which engages the drive train **20**, which thereby drives the tool output shaft **18**.

The drive train **20** includes a first stage of planetary gears **30** and a second stage of planetary gears **35** that reside inside a ring gear **70**. The ring gear **70** does not itself rotate, but defines an outer wall for the planetary gears **30**, **35**. The ring gear **70** is cylindrical and includes a wall with an inner surface that includes elongate teeth or splines **71**. The teeth **31**, **36** of the gears **30**, **35** can substantially mate with the ring gear splines or teeth **71** as the planetary gears **30**, **35** rotate inside the ring gear **70** during power tool operation.

The drive train **20** first stage of planetary gears **30** is typically three planetary gears and the teeth **31** substantially mate with the teeth **26** of the pinion gear **25**. The drive train **20** also includes a gearhead **33** with a gear with splines or teeth and a plate (the plate faces the first stage of gears **30**). The first stage of gears **30** drives the gearhead **33**. The second stage of planetary gears **35** also typically includes three planetary gears with external teeth **36**. The gearhead **33** resides upstream of the first stage of gears **30** and drives the second stage of gears **35**. Thus, the first stage (e.g., set) of gears **30** orbit about the pinion gear **25** (see FIGS. **3** and **4**) and the second stage (e.g., set) of gears **32** orbit about the output gear of the gearhead **33**. In turn, the second stage of gears **35** drive a carrier **40** which drives the tool output shaft **18**. A portion of the carrier **40** also resides within the ring gear **70** with a center hub **40***h* that extends a distance outside the ring gear **70** and holds the tool output shaft **18**.

Referring now to FIGS. **5**-**8**, the mounting of the gearcase **16** to the motor mount **50** will be described in further detail. In FIG. **5**, the housing **12** of the power tool **10** of FIG. **1** is shown as transparent in order to better illustrate the gearcase **16** secured to the motor mount **50** within the tool **10**. The illustrated motor mount **50** includes first and second pairs of locking elements **55** in diametrically spaced apart relationship (FIG. **7**A). The illustrated motor mount **50** also includes a splined opening **53** extending through a medial portion **50***m* thereof, along with passageways **50***p* extending through the motor mount, one on each side of the splined opening **53**. As described above, the motor rotor **22** extends through the opening **53** and couples with the drive train **20** within the gearcase **16**. Fasteners **14***f* (FIG. **4**) are inserted through the passageways **50***p* to secure the motor **14** to the motor mount first side **52**, as described above.

The illustrated locking elements **55** on the motor mount second side **54** are configured to engage with respective gearcase locking elements **17**. Each motor mount locking element **55** includes an arcuate groove **55***g* that slidably receives a respective gearcase locking element **17**. The proximal end portion **16***b* of the gearcase **16** is adapted to contact the motor mount second side **54** between the respective first and second pairs of locking elements **55** then slidably rotate such that the gearcase locking elements **17** rotatably and securely engage the motor mount locking elements **55**.

The gearcase **16** includes respective locking elements **17** spaced around the periphery of the gearcase proximal end **16***b*. Each locking element **17** extends radially outward from the outer surface of the gearcase housing **16***h* and can have a tapered end configuration (FIG. **8**). As illustrated in FIG. **8**, each locking element **17** includes a top wall **17***t*, a front wall **17***f* and an opposite rear wall **17***r*. One or both of the front and rear walls **17***f*, **17***r* may be tapered. Each gearcase locking element **17** is configured to matably engage a respective one of the arcuate grooves **55***g* in the motor mount locking ele-

ments **55**. The tapered configuration of each locking element **17** is such that a portion of the locking element **17** is slightly wider than the groove **55***g*. This tapered configuration causes an interference fit between a gearcase locking element **17** and a respective motor mount locking element **55** as a gearcase locking element is rotated within a respective motor mount locking element groove **55***g*. As a result of this interference fit between gearcase locking elements **17** and respective motor mount locking elements **55**, the gearcase **16** is snugly secured to the motor mount **50**. In addition, the gearcase locking elements **17** and motor mount locking elements **55** are configured to ensure that the drive train **20** within the gearcase **16** is aligned concentrically with the rotor **22** when the gearcase **16** is secured to the motor mount **55**.

The gearcase **16** can be a single unitary and/or monolithic body of aluminum, for example, and can be manufactured by metal injection molding. Of course, machining or other processes with sufficient precision may also be used. The motor mount **50** can be a single unitary and/or monolithic body of steel, for example. Machining or other processes with sufficient precision may also be used. Other materials with sufficient rigidity may be used for each of these components and other processes may be used to form the desired shapes and features.

FIG. **7**A illustrates the gearcase **16** and motor mount **50** prior to attachment to each other. In FIG. **7**B, the gearcase **16** and motor mount **50** are aligned such that the gearcase proximal end **16***b* is in contacting relationship with the motor mount second side **54** and such that each gearcase locking element **17** is positioned to be rotated into a groove **55***g* of a respective motor mount locking element **55**. In FIG. **7**C, the gearcase **16** has been rotated approximately ninety degrees (90°) clockwise such that each gearcase locking element **17** is slidably received within a respective groove **55***g* of each respective motor mount locking element **55**.

Embodiments of the present invention are not limited to the illustrated configuration of the gearcase locking elements **17**, motor mount locking elements **55**, and grooves **55***g*. Various ways of slidably locking the gearcase **16** to the motor mount **50** may be utilized without limitation. Locking elements **17**, **55** with various shapes and configurations may be utilized without limitation. Moreover, different numbers of locking elements **17**, **55** may be utilized. Also, in some embodiments of the present invention, the motor mount locking elements **55** and grooves **55***g* can be on the gearcase housing and the locking elements **17** can be on the motor mount **50**.

Referring to FIGS. **9**A-**9**B, an auxiliary handle **150** configured to be gripped by a user of the tool **10** may be removably secured to the exposed portion (i.e., the distal end **16***a*) of the gearcase **16**. The gearcase **16** provides a rigid support for the auxiliary handle **150**. The illustrated handle **150** includes opposite distal and proximal ends **152**, **154**. An expandable/contractible band **156** extends from the handle proximal end **154** and is configured to surround and grip the gearcase **16** to secure the handle **150** thereto. The handle **150** may include a tightening mechanism **158** therewithin that allows a user to tighten the band **156** around the gearcase **16** when attaching the handle **150** to the tool **10** and to loosen the band **156** such that the handle **150** can be removed from the tool **10**. In some embodiments of the present invention, the tightening mechanism **158** is operated by axial rotation (illustrated by arrow A_1) of the distal end portion of the handle **150**. However, other mechanisms that can expand and contract the band **156** may be utilized in accordance with embodiments of the present invention.

Referring to FIGS. **10**-**15**, a gearcase **16** according to other embodiments of the present invention and for use with a cordless power tool, such as the tool **10** of FIG. **1**, is illustrated. The gearcase **16** is similar in configuration and function to the gearcase **16** of FIGS. **1**-**8**. The illustrated gearcase **16** of FIGS. **10**-**15** has an elongated housing **16***h* with opposite, longitudinally spaced apart distal and proximal end portions **16***a*, **16***b*, respectively. The gearcase housing **16***h* is configured to encase a drivetrain of the power tool **10**, as described above. The proximal end portion **16***b* has an opening **21** configured to receive a rotor **22** (FIG. **3**) from the motor **14** of the power tool **10** that couples with the drive train **20**. The distal end portion **16***a* has an opening **23** through which an output shaft **18** (FIG. **1**) of the power tool **10** extends.

The gearcase **16** of FIGS. **10**-**15** includes respective locking elements **17** spaced around the periphery of the gearcase proximal end **16***b*. Each locking element **17** extends radially outward from the outer surface of the gearcase housing **16***h* and has a tapered configuration as described above with respect to the gearcase **16** of FIGS. **1**-**8**. The gearcase housing **16***h* is configured to be rigidly mounted to the second side **54** of the motor mount **50** (FIG. **5**) via gearcase locking elements **17** that cooperate with and slidably engage motor mount locking elements **55**, as described above.

The gearcase **16** of FIGS. **10**-**15** includes a flange **16***f* that extends around the outer surface of the gearcase housing **16***h* adjacent to the proximal end portion **16***b*, as illustrated. The flange **16***f* can have an arcuate top portion **16***ft*, arcuate side portions **16***fs* and a generally flat bottom portion **16***fb*. The illustrated flange **16***f* also includes a tapered outer surface **15**. The configuration of flange **16***f* and the tapered contour of the flange outer surface **15** are designed to mate with one or more portions **12***m* of the interior **12***i* of the housing **12** of the tool **10** (FIGS. **13**-**15**). The flange **16***f* helps lock the gearcase **16** to the housing and helps prevent the gearcase **16** from moving. Moreover, the mating arrangement of the flange **16***f* and housing portion(s) **12***m* provides strength and rigidity to an assembled tool **10**. The flange **16***f* may have various shapes and configurations selected for locking engagement with a housing of a power tool. Embodiments of the present invention are not limited to the illustrated configuration or location of the flange **16***f* and corresponding internal features of the housing **12**.

The gearcase **16** of FIGS. **10**-**15** also includes a plurality, typically a pair, of mounting lugs or "ears" **16***e* arranged in diametrically opposed relationship at the proximal end portion **16***b*, as illustrated. Each ear **16***e* includes an aperture **16***p* formed therethrough. Each ear **16***e* is configured to align with a respective threaded boss **12***b* (FIGS. **2**, **3**, **13**) in housing section 12_1 and with a respective aperture **12***c* in housing section 12_2 (FIG. **2**) when the gearcase **16** is assembled within the housing **12**. FIGS. **14** and **15** illustrate the gearcase **16** positioned within the housing section 12_1 such that each gearcase ear **16***e* abuts a respective threaded boss **12***b*. Housing assembly screws **13** (FIG. **2**) extend through the apertures **12***c* in housing section 12_2, through the apertures **16***p* in the gearcase ears **16***e*, and threadingly engage with the threaded bosses **12***b* in housing section 12_1. The gearcase ears **16***e* provide a rigid, structurally buttressing connection between the gearcase **16** and the housing **12**, thereby enhancing strength and rigidity of the tool housing **12**. Moreover, the gearcase ears **16***e* help lock the gearcase **16** in the housing **12** and help prevent the gearcase **16** from moving when the tool **10** is assembled.

The gearcase **16** of FIGS. **10**-**15**, including flange **16***f* and ears **16***e*, can be a single unitary and/or monolithic body of aluminum or other relatively light but structurally strong material. The body can be manufactured by metal injection

molding. Of course, machining, forging, casting or other material forming processes with sufficient precision may also be used.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

That which is claimed is:

1. A power tool, comprising:

a motor having an outwardly extending rotor that defines a drive axis;

a housing surrounding the motor; and

a gearcase encasing a drive train coupled to the rotor and configured to drive a tool output, wherein the gearcase has opposing, longitudinally spaced apart first and second end portions, the first end portion encased by the housing and the second end portion exposed to the outside of the tool forward the housing, wherein the gearcase first end portion comprises a pair of mounting lugs extending outwardly therefrom that are secured to an interior of the housing.

2. The power tool of claim **1**, further comprising a motor mount having opposite first and second sides, wherein the motor is secured to the motor mount first side, wherein the gearcase is secured to the motor mount second side, and wherein the rotor extends through the motor mount to couple with the drive train.

3. The power tool of claim **2**, wherein the gearcase is secured to the motor mount second side such that the drive train is aligned concentrically with the rotor.

4. The power tool of claim **2**, further comprising interengageable locking elements on the gearcase and motor mount second side that hold the gearcase securely to the motor mount.

5. The power tool of claim **4**, wherein the gearcase locking elements are spaced peripherally from each other at the first end portion of the gearcase and are engageable with the motor mount locking elements by rotative motion of the gearcase relative to the motor mount.

6. The power tool of claim **4**, wherein each gearcase locking element extends outward axially from a periphery of a rear end of the gearcase, and wherein each motor mount locking element comprises an arcuate groove configured to slidably receive a respective gearcase locking element therein.

7. The power tool of claim **6**, wherein the gearcase locking elements have a tapered configuration sized to cause an interference fit with the motor mount locking elements.

8. The power tool of claim **1**, further comprising an auxiliary handle removably secured to the gearcase that is configured to be gripped by a user of the tool.

9. The power tool of claim **8**, wherein the auxiliary handle is secured to the gearcase via a band surrounding the gearcase, and wherein the handle comprises a tightening mechanism connected to the band for tightening and loosening the band relative to the gearcase.

10. The power tool of claim **1**, wherein the housing comprises two substantially symmetrical sections releasably engaged.

11. The power tool of claim **1**, wherein the gearcase comprises an outwardly projecting circumferentially extending flange that engages an interior portion of the housing.

12. The power tool of claim **1**, wherein the power tool is a cordless power tool.

13. A gearcase for a power tool, the gearcase comprising:

an elongated housing having opposite, longitudinally spaced apart first and second end portions, wherein the housing is configured to encase a drivetrain of the power tool, wherein the first end portion has an opening configured to receive a rotor from a motor of the power tool that couples with the drive train, and wherein the second end portion has an opening through which an output shaft of the power tool can extend; and

a plurality of locking elements at the housing first end portion configured to secure the housing to a motor mount of the power tool,

wherein the first end portion of the housing comprises a pair of mounting lugs extending outwardly therefrom that are configured to be secured to an interior portion of a housing of the power tool.

14. The gearcase of claim **13**, wherein the locking elements are spaced peripherally from each other at the first end portion of the housing and are rotatably engageable with respective locking elements on the motor mount.

15. The gearcase of claim **13**, wherein the locking elements extend outward axially from a periphery of the first end portion of the housing.

16. The gearcase of claim **13**, wherein the locking elements have a tapered configuration that cause an interference fit with respective motor mount locking elements.

17. The gearcase of claim **13**, wherein the gearcase housing comprises an outwardly extending flange configured to engage an interior portion of a housing of the power tool.

18. A motor mount for a power tool, the motor mount, comprising:

a base having opposite first and second sides, wherein the first side is configured to be attached to a motor of the power tool, and wherein the second side is configured to be attached to a gearcase that encases a drivetrain of the power tool, wherein an opening extends through the base between the first and second sides and is configured to receive a motor rotor therethrough that couples with the drive train; and

a plurality of locking elements at the base second side configured to secure the gearcase to the base, wherein the opening is a splined opening.

19. The motor mount of claim **18**, wherein the locking elements are spaced from each other and are engageable with respective gearcase locking elements by rotative motion of the gearcase relative to the motor mount.

20. The motor mount of claim **18**, wherein each motor mount locking element comprises an arcuate groove configured to slidably receive a respective gearcase locking element therein.

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